EXHIBIT A

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Confidential Invention Disclosure **University of Illinois at Urbana-Champaign**

1. TITLE OF INVENTION:
   Methods to manufacture photocatalysts

2. NON-CONFIDENTIAL DESCRIPTION
   Synthetic methods to produce photocatalysts with high surface areas.

3. INVENTOR(S):

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Contribution:	Co-PI

4. DATES OF CONCEPTION, REDUCTION TO PRACTICE, AND PUBLIC DISCLOSURE

		Date
Date of conception of invention: Is this date documented in writing? If so, where?	[redacted] Yes. Research notebook	
Date of first reduction to practice:	[redacted]	
Dates of disclosure (oral, written, or electronic) and names of persons or companies to whom disclosed *under a confidentiality agreement*:	N/A	
Dates of disclosure (oral, written, or electronic) and names of persons or companies to whom disclosed *without a confidentiality agreement*:	N/A	
Date first publication was submitted and date published (electronic, print, thesis or other media)	N/A	
If unpublished and undisclosed, provide the anticipated disclosure date and any submissions already made for potential publication	Submission of research publications planned for [redacted]	

5. [redacted]

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6. SPONSORSHIP

Agency or Sponsor	Grant/Contract/Other Number	UFAS No.
National Science Foundation	Science and Technology Center	1-5-29555
	on Water Purification	
	CTS-0120978	

7. FUTURE FUNDING

NSF-STC-Water Purification, CTS-0120978; optimization of the methods, basic research on structure and properties of photocatalysts; applications to water purification.

8. GENERAL SUMMARY OF THE INVENTION

The purpose of this invention is to make new photocatalysts with much higher catalytic efficiency. The invention provides a new processing technique and several new synthetic pathways for manufacturing photocatalysts in a high surface area form. Using this technique, mesoporous fibers of photocatalysts have been made for the first time with very high surface areas.

9. PRIOR METHODS OR APPARATUS

Photocatalysts were first discovered in 1970s. Since then, a number of synthetic methods have been developed which have led to commercialization of photocatalyst powder forms by US, Japanese and German companies. The primary drawbacks of these products are that 1) powder form is difficult to apply in a number of targeted applications such as water and air purification, 2) the surface area of the powder is low, resulting in a low catalytic activity and small number of active catalytic sites.

10. DISADVANTAGES OR LIMITATIONS

Advantages: Very high surface area; active under visible light; low-cost; fiber form; high wear and mechanical strengths; high thermal stability.

Limitations: Requiring activation by light. The problem is easily solved by installing lamps or using transparent vessels.

11. BEST MODEL

The typical synthesis process starts with a low-cost glass fiber substrate, including felt, paper and fabric. The first step is to apply a carbonaceous precursor coating to the glass fiber surface. Upon activation, activated carbon fibers with uniform micropores and mesopores are produced. The pore dimension and volume are controlled by adjusting the processing variables in the activation process, such as temperature, time and activator to produce interconnected open pores with average dimensions ranging from 5 Å to 50 nm. Those fibers with the desired pore dimensions and volumes are selected as the templates for preparing photocatalyst fibers.

In the next step, the porous carbon template is infiltrated with the desired precursors by wet impregnation. For photocatalysts such as TiO_2, the typical precursors are organometallic compounds such as titanium tetraisopropoxide or inorganic solutions such as $TiO(NO_3)_2$. After removing the excess precursor, the hydrolysis of precursor is initiated by exposure to the moisture in air. Upon conversion, a composite of carbon and photocatalyst is produced. The photocatalyst should fill the pores in the template to form an interconnected solid (Fig. 1). Along a given cross-section, the photocatalysts appear as a well-dispersed distribution of nanometer-sized particles, as shown in Fig. 2. The mesoporous fibers are obtained by crystallization or polymerization of inorganic species at high temperatures 400-600 °C in nitrogen, coupled with removal of carbon at 550 °C in air. The fibers typically contain average pore dimensions of a few nanometers as shown in Fig. 3, with surface areas from as low as 50 m^2/g to over 1000 m^2/g. During the synthesis, dopants such as nitrogen and sulfur can be introduced either by mixing a dopant source with the polymer precursor or by reacting the oxide photocatatalyst with the dopant source. Similarly, fine particles of other catalysts such as Pt, Au, Pd, V_2O_5-WO_3 particles can be added to the mesoporous fibers using precursors such as platinum acetylacetonate, $HAuCl_4$, vanadium oxytriisopropoxide, and tungsten ethoxide.

In an alternative process, activated carbon fibers are used as the templates. Following similar synthetic pathways as described above, porous fibers of photocatalysts are produced. Using other organic and inorganic solids such as carbon fines and polymeric fibers, high surface area catalysts are made as solid or hollow fibers, solid or hollow particles, and coatings.

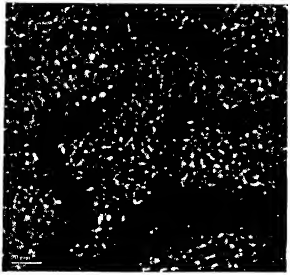

Fig. 1. Pore structure of the mesoporous photocatalyst on the surface of glass fiber.

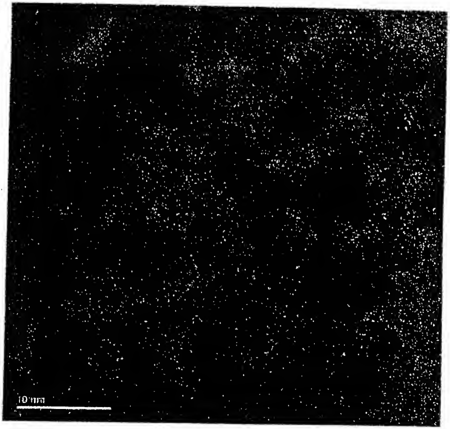

Fig. 2. Distribution of photocatalyst nanocrystals in the template.

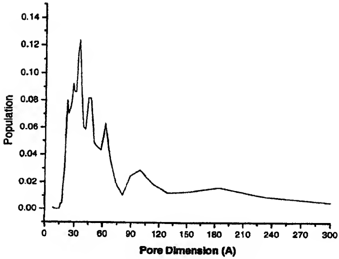

Fig. 3. Pore size distribution in mesoporous photocatalyst.

12. STAGE OF DEVELOPMENT

New high surface area catalysts have been made in fiber and fabric forms. We can produce these new materials in fabrics of a few square inches. The processing variables need to be optimized for a given target application before scaling-up.

13. POTENTIAL LICENSEES

Catalysts manufacturers and users; manufacturers of water purification systems and air purifiers.

14. THE DISCLOSURE SHOULD BE SIGNED AND DATED BY THE INVENTOR(S), AND THEN READ AND SIGNED BY A NON-INVENTOR WITNESS.

I (We) hereby agree to assign all right, title and interest to this invention to UI and agree to execute all documents as requested, assigning to UI our rights in any patent application filed on this invention, and to cooperate with the OTM in the protection of this invention. UI will share any royalty income derived from the invention with the inventor(s) according to the General Rules, Article III, Section 8.

Inventor(s) Signature	Date	Witness
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Unit Executive Officer(s) Signature	Date	Printed Name & Unit
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